CLAIMS

We claim:

1. Apparatus for obtaining information about a fluid issuing from a moving dispenser during printing, comprising:

a dispenser for dispensing fluid, the dispenser having an orifice wherein the fluid flows out of the orifice of the dispenser and moves away from the orifice of the dispenser in a substantially vertical path;

a light source directing light toward the path of the fluid;

a receiver optical fiber having a first end and a second end, the first end of the receiver optical fiber being proximately positioned to maintain a relative distance from the path of the fluid, the first end of the receiver optical fiber receiving variations in light intensity as the dispensed fluid blocks a portion of the light, the second end of the receiver optical fiber connected to a light receiving device for monitoring the variations in light intensity, wherein a length of fiber between the first end and the second end of the optical fiber is sufficiently flexible to accommodate movement of the dispenser.

2. The apparatus of claim 1, wherein the light source is transmitted through a transmitter optical fiber, the transmitter optical fiber being proximately positioned to maintain a relative distance from the path of the fluid.

3. The apparatus of claim 1, wherein the light source is a light emitting diode.

4. The apparatus of claim 1, wherein the receiver optical fiber is an incoherent optical fiber.

5. The apparatus of claim 4, wherein light from the light source is emitted in a beam that is substantially continuous in time.

6. The apparatus of claim 4, wherein light from the light source is emitted in a stroboscopic pattern that varies with time and the light receiving device produces an analog signal wherein peaks in the analog signal correspond to a dispensed fluid unit.

7. The apparatus of claim 6, further including a controller for controlling the fluid dispensing from the dispenser and wherein the stroboscopic light source pattern is triggered by commands given to the dispenser.

8. The apparatus of claim 1, wherein the light receiving device is a light intensity transducer wherein the light intensity transducer produces an analog time-dependent electrical signal whose magnitude is related to an intensity of the light exiting the optical fiber.

9. The apparatus of claim 8, further comprising a Fourier transform device that transforms the time-dependent electrical signal into a frequency spectrum.

10. The apparatus of claim 8, further comprising a discretizer that identifies parts of the time-dependent electrical signal as dispensing of a fluid unit.

11. The apparatus of claim 10, further comprising a counter, which counts the number of times the discretizer identifies parts of the time-dependent electrical signal as dispensing of a fluid unit.

12. The apparatus of claim 10, further comprising a recording device that records the discretizer identifying parts of the time-dependent electrical signal as dispensing of a fluid unit.

13. The apparatus of claim 12 wherein the recording device further records the spatial location of the dispenser at the time of the discretizer identifying parts of the signal as dispensing of a fluid unit.

14. The apparatus of claim 13 wherein the recording device further records commands for dispensing to compare actual dispensed fluid to theoretical commanded dispensed fluid.

15. The apparatus of claim 1 wherein the receiving optical fiber is a coherent optical fiber bundle.

16. The apparatus of claim 15 wherein the light source emits light in a substantially continuous beam.

17. The apparatus of claim 15 wherein the light source emits light in a stroboscopic pattern.

18. The apparatus of claim 17 wherein the stroboscopic light source is triggered by commands given to the dispenser.

19. The apparatus of claim 15 wherein the light receiving device is a camera.

20. The apparatus of claim 19, further including an image processing device connected to the camera.

21. The apparatus of claim 20, wherein the image processing device is capable of measuring diameter or cross-sectional area or other dimensions of fluid structures.

22. The apparatus of claim 1, wherein a plurality of dispensers are mounted in a printhead and the printhead contains more than one light source and an optical fiber associated with each light source.

23. A method of obtaining visual information about a fluid from a moving printhead as the printhead is printing product, comprising:

dispensing the fluid from the printhead along a fluid path;

shining light from a light source toward the fluid path such that the light beam intersects that fluid path;

receiving light into an optical fiber, as the fluid passes through the light;

moving the printhead wherein the optical fiber is flexible and has two ends and one end is able to move with the printhead during operation; and

carrying the received light to a light receiving device.

24. A method of counting fluid units dispensed from a moving printhead, comprising:

dispensing the fluid from the printhead along a fluid path;

shining light from a light source toward the fluid path such that the light beam intersects that fluid path;

receiving light into an optical fiber, as the fluid passes through the light;

moving the printhead wherein the optical fiber is flexible and has two ends and one end is able to move with the printhead during operation;

carrying the received light to a light receiving device;

converting the received light to a discretized signal representing dispensed fluid units; and

counting the number of dispensed units.

25. A method of determining a flow characteristic of a fluid stream dispensed from a moving printhead, comprising:

dispensing a fluid from a printhead along a fluid path;

shining light from a light source toward the fluid path such that the light beam intersects the fluid path;

receiving light after it passes the fluid blocks a portion of the light from the receiving optical fiber, the optical fiber bending to accommodate movement of the printhead;

carrying the received light to a fixed instrument;

converting the received light to a time-dependent electrical signal;

analyzing the time-dependent electrical signal in the form of a frequency spectrum having various harmonics; and

comparing the relative magnitudes of various harmonics in the frequency spectrum to determine the flow characteristics of the fluid stream.

26. A method of bring visual information to a camera from a printhead as the printhead is printing product, using a coherent optical fiber bundle, comprising;

obtaining a picture of fluid dispensing near a printhead while the printhead is actually printing a product; and

transmitting the picture from a moving printhead through a coherent optical fiber bundle while the coherent optical fiber bundle is bending or changing shape as the picture is being transmitted through it.

27. The method of claim 26 further including using visual dimensional data with records of numbers and timing of drops to calculate volumetric flow rate or velocity or other stream characteristics of the fluid being dispensed.

28. The method of claim 26 further including using colorimetric analysis of the returned light to obtain information about the chemical content of the fluid being dispensed.

29. The method of claim 26 further including using any of the data as feedback to control or adjust printing parameters, or as a quality assurance record of the printing process.

30. A method of controlling the output of a three-dimensional printer, comprising:

measuring a characteristic of a discharged fluid by optical means; and

adjusting an operating parameter of the three-dimensional printer in response to the measured characteristic of the discharged fluid.

31. A verification system for use with a three-dimensional printer, comprising:

means for determining a delivery of units of a fluid;

means for recording information about the delivery of units of the fluid; and

means for comparing the information about the delivery of units of fluid with information about command for delivery of units of fluid.

32. A method of obtaining information about a dispensed fluid, comprising:

projecting a light beam across a fluid path;

dispensing fluid from a dispenser upon a command signal through the fluid path;

receiving variations in light intensity due to the dispensed fluid moving through the light beam; and

producing an analog signal from the received variations in light intensity.

33. The method of claim 32 wherein an incoherent optical fiber receives the variations in light intensity.

34. The method of claim 33 wherein the analog data from the incoherent fiber is used to estimate flow rate by processing the signal using algorithms to integrate a dispensing interval.

35. The method of claim 32 wherein a coherent fiber bundle receives the variations in light intensity to provide an image of the dispensed fluid.

36. The method of claim 35 further including calculating fluid dimensions from the variations in light intensity.

37. The method of claim 35 further including displaying multiple images on one display screen.

38. The method of claim 32 further including, discretizing the analog signal by comparing an instantaneous magnitude of the analog signal against a threshold value so as to indicate either the presence or absence of a drop.

39. The method of claim 32 further including, recording a binary signal from the received variations in light intensity.

40. The method of claim 32 further including counting fluid units crossing the fluid path in real-time.

41. The method of claim 32 wherein the analog signal goes through a Fourier Transform and/or other signal processing algorithms for the purposes of diagnosing a regime of the dispensed fluid, wherein the regime is one of individual droplets, satellites, connected bulges, intermittent streams, connected drops or streams.

42. The method of claim 32 wherein a coherent fiber bundle receives the variation in light intensity to provide a one-dimensional line array of individual fibers, wherein the one-dimensional line array can detect split-streaming or off-axis streaming of the dispensed fluid.